§21. Properties of High-n Pressure-driven Eigenmodes in 3D Equilibria

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Properties of high-n ideal pressure-driven eigenmodes in Mercier-stable and Mercier-unstable three-dimensional equilibria are investigated by using an LHD configuration with $R_{axis} = 3.75$m, where n is the toroidal mode number. The Mercier-stable equilibrium is created under the currentless condition with the peaked pressure profile: $\beta(r) = \beta_0(1 - r^2)^2$ with $\beta_0 = 8\%$, and the Mercier-unstable equilibrium is created under the currentless condition with the broad pressure profile: $\beta(r) = \beta_0(1-r^4)^2$ with $\beta_0 = 4\%$ or $\beta(r) = \beta_0(1 - r^2)(1 - r^{18})$ with $\beta_0 = 8\%$. The ideal MHD stability is investigated by using CAS3D2MN code under the fixed boundary condition. In these circumstances, only pressure-driven modes are destabilized, which are searched for the Fourier space of the perturbation with $n \gtrsim M$ or $n \gg M$, where M is the toroidal field period. As typical toroidal mode number n increases, both poloidal and toroidal mode couplings between equilibrium and perturbation become stronger, so that unstable eigenmodes have purely three-dimensional properties. Namely, eigenfunctions consist of many groups of Fourier modes with the different toroidal mode numbers, and each group consists of various Fourier modes with different poloidal mode numbers for $n \gtrsim M$ or $n \gg M$, leading to the existence of many unstable eigenmodes. Thus, the semi-quantization condition of ballooning modes, which can be approximately applied to low-n eigenmodes with $n \lesssim M$ [1], can not be applicable to such high-n eigenmodes, in order to distinguish various eigenmodes. However, the structure of eigenmodes is understandable from the viewpoint of the number of the radial nodes of Fourier-mode group with the same toroidal mode number. Most unstable mode consists of Fourier-mode groups with no radial node number. Other modes with smaller growth rate also consist of various Fourier-mode groups, however, some of groups have radial nodes as is shown in Fig.1. Figure 1-(a) shows the radial profile of the Fourier components of the radial displacement: $(\vec{\xi} \cdot \nabla\psi)_{mn}$ of the second most unstable three-dimensional ballooning modes. The radial profile of one of the Fourier-mode group with the toroidal mode number $n = -76$ is indicated in Fig.1-(b), where one radial node exists. As the growth rate decreases, the number of the Fourier-mode groups with radial nodes increases, and the number of the radial nodes in each group also increases. The same properties are observed for the tree-dimensional interchange modes. Note that the number of unstable eigenvalues in Mercier-stable equilibria is much fewer than that in Mercier-unstable equilibria, under the almost same Fourier space of the perturbation. In Mercier-unstable equilibria, three-dimensional ballooning modes localized in the outer side of torus change into three-dimensional interchange modes localized in the inner side of torus, as the radial nodes of Fourier-mode groups increases. Moreover, interchange modes consisting of Fourier-mode groups with multiple radial nodes can be destabilized, because their driving force is related with the unfavorable *average* magnetic curvature. These two facts leads to the above difference.

Fig.1-(a)

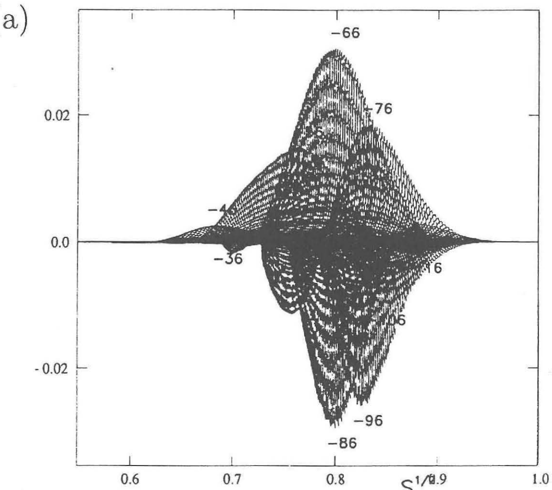
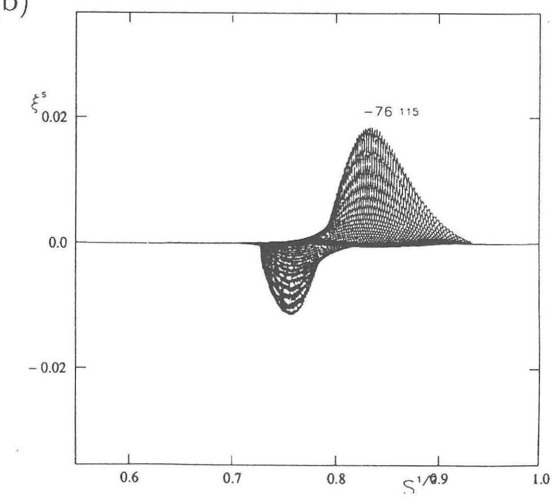


Fig.1-(b)



[1] Properties of low-n pressure-driven eigenmodes in Mercier-unstable 3D equilibria, Nakajima N. in this annual report.